Navigation Team Was Unfamiliar with Mars Climate Orbiter

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The Mars Climate Orbiter was lost at the Red Planet nearly seven weeks ago because the mission's navigation team was unfamiliar with the spacecraft. It lacked training, and failed to detect a mistake by outside engineers who delivered navigation information in English rather than metric units, according to a mission failure investigation report released Wednesday.

A litany of errors and problems led to the loss of the $125 million spacecraft on Sept. 23, a loss that has complicated an upcoming Mars landing mission, the report says. The report was released Wednesday during a press conference at NASA Headquarters in Washington, D.C.

While the root cause of the failure was the units mix-up between navigation teams, the real problem was a systemic failure to follow NASA procedures, said Ed Weiler, NASA's Associate Administrator for Space Science.

Edward Weiler

Checks and balances processes that should have caught such errors were not followed, Weiler said. However he and the report's authors avoided assigning blame, instead indicting all of NASA for the failure.

"No individual, nor individuals are to blame. The entire Mars Climate Orbiter team, NASA, JPL, contractors and the science team are to share in the responsibility for this failure," Weiler said.

Still, the details of the report seem to point solidly to a flight operations team at Lockheed Martin, and the navigation team at the Jet Propulsion Laboratory. Lockheed Martin built the spacecraft and controlled some of its operations for JPL.

Mission specifications called for using metric units, but the Lockheed group sent navigation information in

(available here, 479kb) and press conference (see the video) reveal more about the failure of the craft."
English units. The mix-up meant that Lockheed engineers modeled navigation with pounds force (the English unit for measuring thruster impulse) while JPL did its calculations in newtons (the metric measurement). One pound force is equivalent to 4.45 newtons.

The result was that the changes made to the spacecraft's trajectory were actually 4.4 times greater than what the JPL navigation team believed.

One of the most glaring criticisms to come out of the day's announcements was made by Arthur Stephenson, Chairman of the Mission Failure Investigation Board and Director of NASA's Marshall Space Flight Center, who blamed many of the problems on the navigation team's unfamiliarity with the spacecraft.

The navigation operations team came on the program just two months before launch, Stephenson said. Its members had not been involved in any of the orbiter's design reviews, and "they actually assumed that the spacecraft was much like the Mars Global Surveyor, which is really a different spacecraft," he said.

The JPL navigators realized back in April that there was a problem in synchronizing the data from Lockheed Martin with their own, Stephenson said. Even though the two teams had a meeting to try to determine the cause of the problem, "this anomalous situation was never resolved."

Furthermore, the navigation team failed to follow procedures that would have alerted the rest of the mission to their concerns, and the team was never the subject of a peer review.

The mission team also failed to perform a final thruster firing, and communications between team members were inadequate, the report said. The report also found the navigation team's staffing, training and communications between project elements to be "inadequate."

"Even so, there were many things in place that should have caught this error," Stephenson said, but these procedures were never followed. A factor that likely contributed to the host of mistakes, was that the navigation team was responsible for three missions, not just one. The team responsible for the Mars Global Surveyor was put in charge of both the Mars Climate Orbiter and the Mars Polar Lander.

This was probably asking too much of the team, Stephenson said. Members felt stressed and overworked, which undoubtedly contributed to the errors. Still, he emphasized that the report was not meant to be an indictment of JPL, but should be used to ensure that natural mistakes are detected and remedied before they destroy a spacecraft.

When pressed by reporters about what action NASA would take, Weiler was adamant that the report's conclusions are not to be applied personally.

"The bottom line is, should we fire people?" Weiler asked rhetorically. "Who will we replace them with? These are the best people in the world, Nobody does it better," he said of JPL engineers.

"Humans make errors, humans make bad judgements sometimes. We have to find why those errors weren't caught."

JPL Director Edward Stone also emphasized that the focus of the investigation and the report should be on safeguarding the Mars Polar Lander, which is just three weeks away from landing on Mars.
Edward Stone

"It was an inadequate system of checks and balances which led to the fact that we didn't recognize that we were on the wrong trajectory," Stone said. "What we need to do right now, of course, is focus on making sure all those checks and balances are there for the landing on December 3 -- and that's exactly what we're going to do."

To view a copy of the investigation board's full report (479 Kb PDF file) click here.

The Mars Climate Orbiter was lost and presumed destroyed when it shot within 35 miles (57 kilometers) of the martian surface as controllers were attempting to put it into orbit. At that altitude, the craft -- which was traveling at least 10,000 mph -- would have been torn apart in the planet's atmosphere. The minimum survivable altitude was about 53 miles (85 kilometers), mission operators said, while the original target altitude was about 125 miles (200 kilometers).

Mars Climate Orbiter

To view an animated movie of what likely happened to the Mars Climate Orbiter created for space.com by Analytical Graphics choose: low-res (294 Kb) or high-res (7.4 Mb).

The loss has complicated the mission of the Mars Polar Lander, which is on its way to Mars and scheduled to touch down December 3. Mission officials insist that the same problems that doomed the orbiter will not affect the lander, but the two spacecraft were part of the same mission and were designed to work together.

The Climate Orbiter was to have served as a communications and data relay station between the Polar Lander and Earth. Without the orbiter, controllers and mission scientists have had to scramble to re-design all the sequences of the lander's operations.